Midterm Review Problems – Solutions

Unit 1: 1-D Kinematics (Problems 1-5)

2. A car traveling at a rate of 20m/s accelerates at a rate of $3m/s^2$ in order to pass another car. If this acceleration last for 4 seconds, what is the velocity of the passing car at the end of those 4 seconds?

$a = 3 m/s^2$
$V_0 = 20 m/s$
$\Delta t = 4 s$
$V = ?$

$$\boxed{V = V_0 + at} \Rightarrow V = 20 m/s + (3 m/s^2)(4s)$$

$$\boxed{V = 32 m/s}$$

3. How long does it take a racehorse to travel a distance of 300m if it is running at a constant speed of 22m/s?

$\Delta x = 300 m$
$\overline{V} = 22 m/s$
$\Delta t = ?$
$V_0 = 22 m/s$
$V = 22 m/s$

$$\boxed{\overline{V} = \frac{\Delta x}{\Delta t}} \quad 22 m/s = \frac{300 m}{\Delta t}$$

$$\boxed{\Delta t = 13.6 s}$$

4. A trapeze artist slips, falls, and lands on a net far below. The performer's velocity is -20m/s when he first touches the net. If the net slows down the performer at a rate of $90m/s^2$, how far does the performer travel after touching the net and before coming to a complete stop?

$V_0 = -20 m/s$
$V = 0 m/s$
$a = 90 m/s^2$
$\Delta y = ?$

$$\boxed{V^2 = V_0^2 + 2a\Delta y}$$

$$(0 m/s)^2 = (-20 m/s)^2 + 2(90 m/s^2)\Delta y$$

$$\Delta y = -2.22 m \Rightarrow \boxed{d = 2.22 m}$$

5. A grape is shot directly upward in the absence of air resistance. After 15 seconds, the grape returns to the same elevation from which it was launched. How high above the launch point did the grape travel?

Consider the fall...
$V_0 = 0 m/s$
$\Delta t = 7.5 s$
$a = -9.8 m/s^2$
$\Delta y = ?$

$$\boxed{\Delta y = V_0 t + \tfrac{1}{2}at^2}$$

$$\Delta y = 0(7.5s) + \tfrac{1}{2}(-9.8 m/s^2)(7.5s)^2$$

$$\Delta y = -276 m \Rightarrow \boxed{d = 276 m}$$

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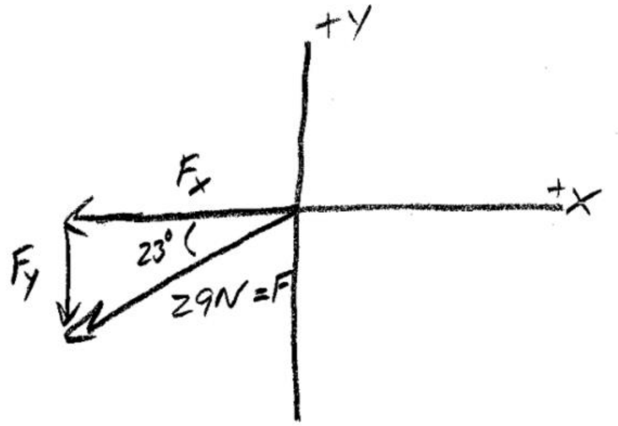
Unit 2: 2-D Kinematics

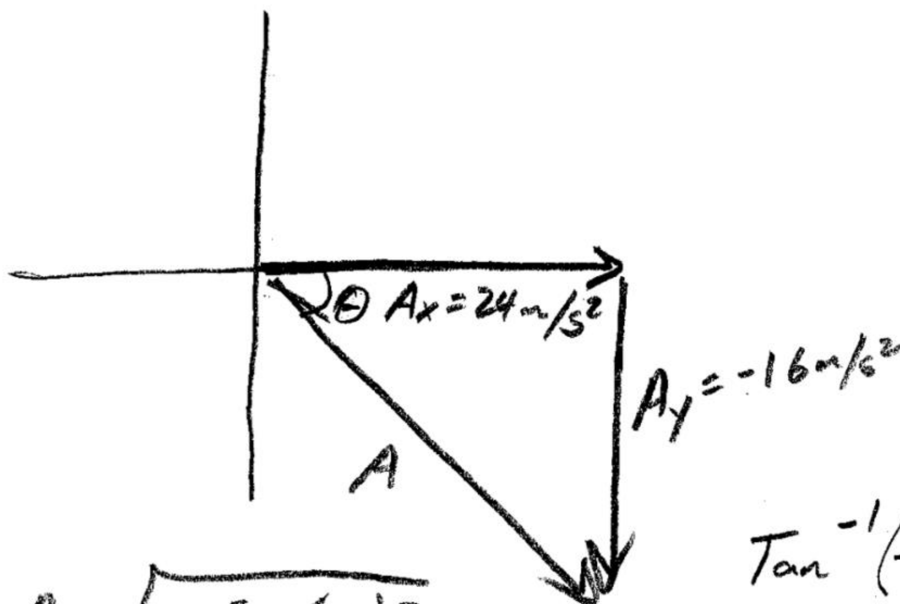
New Unit 2 Practice #1



$F_x = 29N \cos(23°) = \boxed{26.7N}$

$F_y = 29N \sin(23°) = \boxed{11.3N}$

New Unit 2 Practice #2



$\tan^{-1}\left(\frac{16}{24}\right) = \theta$

$\theta = 33.7°$

$A = \sqrt{24^2 + (-16)^2}$

$\boxed{A = 28.8 m/s^2}$

Direction is 33.7° below positive x

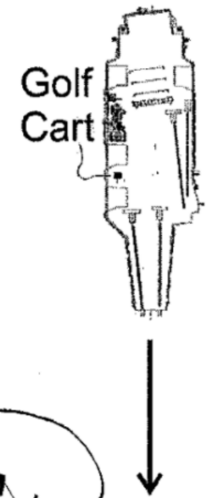
Unit 2 Test Problem #1

1. (8 Points) An aircraft carrier is traveling at a rate of 10m/s southward. An airman driving a golf cart uses a compass to head eastward across the moving carrier, perpendicular to the carrier's length. The golf cart's speedometer reads 6m/s.

C

C

R



a. What is the **actual speed of the golf cart, relative to the Earth**?

$\sqrt{6^2+10^2} = 11.7 m/s$

b. What is the golf cart's direction of travel? Describe the direction in degrees relative to North, South, East, or West.

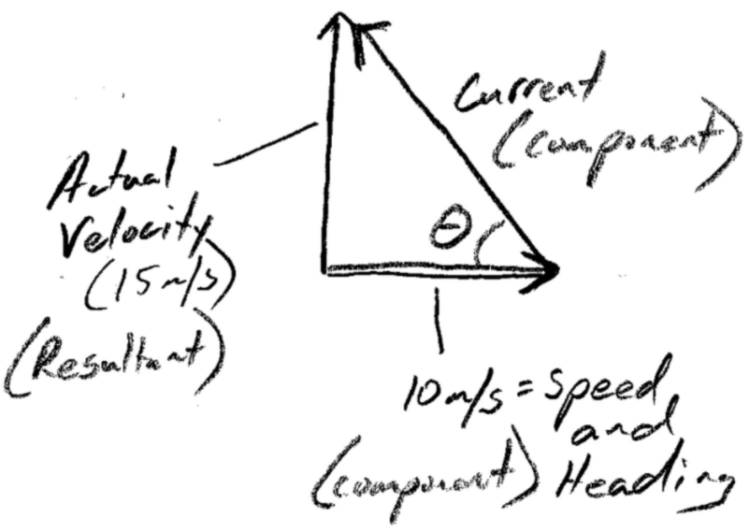
$\theta = \tan^{-1}\left(\frac{6}{10}\right) = 31° \text{ E of S}$

or

59° S of E

Unit 2 Test Retake, Problem #1

Unit 2 Retake Problem #1



$$\text{Current} = \sqrt{15^2 + 10^2}$$

$$= 18.0 \text{ m/s}$$

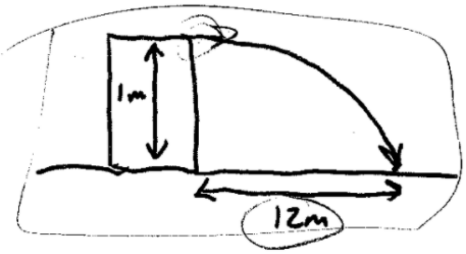
$$\theta = \tan^{-1}\left(\frac{15}{10}\right)$$

$$\theta = 56^\circ$$

Direction = 56° N of W

Unit 2 Test, Problems 3&4

3. (~~8~~ 6 pts) You shoot a projectile horizontally from a table top. The projectile flies 12m horizontally before it hits the floor. The point of impact on the floor is 1m lower in elevation than the projectile's release point.



3 a. How long is the projectile in the air?

$\Delta y = V_{oy} t + \frac{1}{2} a t^2$

$-1m = 0 + \frac{1}{2}(-9.8 m/s^2) t^2 \Rightarrow t = 0.452 s$

1.57 −1½

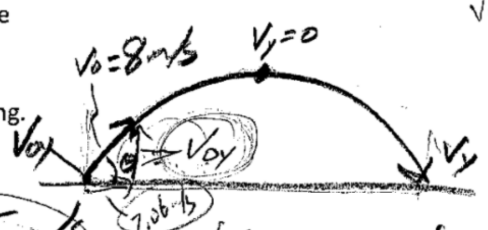
3 b. What was the projectile's initial speed as it left the launcher?

$d = rt$

$12m = r(0.452 s) \Rightarrow 26.5 m/s$

−3 used $V_i t + \frac{1}{2}(-9.8)t^2$

4. (~~8~~ 6 points) An athlete executing a long jump leaves the ground at a 28.0º angle above horizontal and with an initial speed of 8m/s. His landing point is at the same elevation as his take-off point. Determine the following.



3 a. What was his total time aloft?

$V_{oy} = 8 m/s (\sin 28°) = 3.75 m/s$

$V_y = -3.75 m/s$

$a = -9.8 m/s^2$

$V_y = V_{oy} + at$

$-3.75 m/s = 3.75 m/s + (-9.8 m/s^2)(t)$

$t = 0.766 s$

−1 for using V_0 −1 for ½ time

3 c. What horizontal distance did he travel?

$\text{range} = \frac{V_0^2 \sin 2\theta}{g} = \frac{(8 m/s)^2 (\sin(56°))}{9.8 m/s^2}$

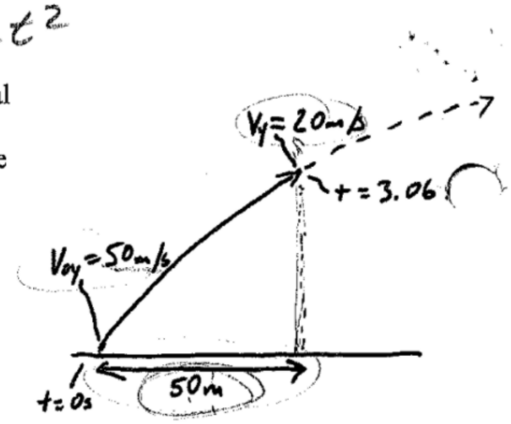
$= 5.41 m$

12

Unit 2 Test, Problem #5

$\Delta y = V_0 t + \frac{1}{2} a t^2$

5. (6 pts) A projectile is launched from the ground with an initial y velocity of 50m/s. After 3.06 seconds, the projectile's y velocity has decreased to 20m/s. During this 3.06 second time period, the projectile has traveled a horizontal distance of 50m.



a. What is the projectile's height at the moment when its y velocity is 20m/s?

$$V_y^2 = V_{0y}^2 + 2a\Delta y$$

$$(20\text{m/s})^2 = (50\text{m/s})^2 + 2(-9.8\text{m/s}^2)\Delta y$$

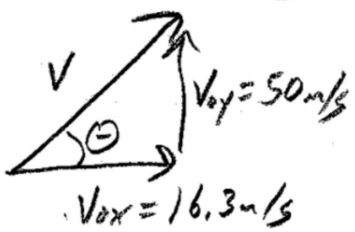
$$\Delta y = 107\text{m}$$

b. What is the projectile's initial speed?

In the x dimension, $d = rt$...

$$(50\text{m}) = r(3.06\text{s})$$

$$r = 16.3\text{m/s} = V_{0x}$$



$$V = \sqrt{50^2 + 16.3^2}$$

$$= 52.6\text{m/s}$$

$16.3 = -1$

c. At what angle (relative to horizontal) was the projectile launched?

$$\Theta = \tan^{-1}\left(\frac{50}{16.3}\right) = 71.9°$$

Unit 3: Newton's Laws in 1-D

Unit 3 Test, Problems 1-2

1. A student weighs 800N on Earth

a. What is his mass?

2

$W = mg$ $800N = m(9.8 m/s^2)$

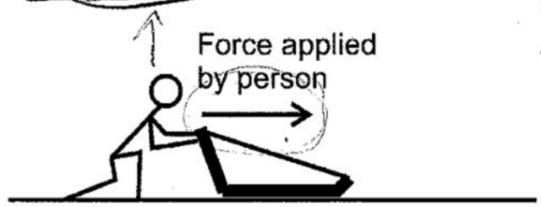
$m = 81.6 kg$

b. On Neptune, falling objects accelerate 1.14 times faster than they do on Earth ($g_{Neptune} = 1.14 g_{Earth}$). How much would same student weigh on Neptune?

2 $W = mg$ $g_{Neptune} = 1.14(9.8 m/s^2) = 11.17 m/s^2$

$W = 81.6 kg(11.17 m/s^2) = 912N$

2. A **15kg** sled is being pushed horizontally by a person.



a. In a frictionless environment, how much force must the person apply in order accelerate the sled horizontally at a rate of $3m/s^2$?

2

$\Sigma F = ma = 15kg(3 m/s^2)$

$= 45N$

b. If the coefficient of friction between the sled and the ground is μ_k=0.4, calculate the force of friction while the sled is sliding horizontally to the right.

2

$F_N = 147N$

$F_{Fr} = \mu_k F_N$

$F_{Fr} = 0.4(147N)$

$= 58.8N$ leftward

$147N = W = mg$ (15kg, 9.8 m/s²)

c. If μ_k=0.4, what force does the person need to apply in order to move the sled, horizontally, at a constant velocity?

2

$\Sigma F = ma = 0$

$\Sigma F = F_{push} - F_{Fr}$

$F_{Fr} = 58.8N$ $F_N = 147N$ F_{push} $W = 147N$

$F_{push} - 58.8N = 0$

$F_{push} = 58.8N$

10.5, 8

-1½

Unit 3 Test, Problems 3-5

3. Consider the same 15kg sled, with μ_k=0.4. The person applies a constant force that accelerates the sled from an initial velocity of 2m/s to a final velocity of 5m/s over a distance of 12m.

(4)

(2) a. Calculate the sled's acceleration over this distance.

$V^2 = V_0^2 + 2a\Delta x$ $(5 m/s)^2 = (2 m/s)^2 + 2a(12 m)$

$a = 0.875 m/s^2$

(2) b. What force does the person apply to the sled in order to cause that acceleration?

$\Sigma F = ma = 15kg(0.875 m/s^2)$ F_{fr} 58.8N, $F_N = 147N$, F_{person} 13.125 = (-1)

$\Sigma F = \text{sum} = F_{person} - F_{fr}$ $W = 147N$

$F_{person} - 58.8N = 15kg(0.875 m/s^2)$ $F_{person} = 71.9N$

4. (4) (2) A student who weighs 600N is standing on a bathroom scale in an elevator, and the scale currently reads 900N.

a. What is elevator's current acceleration? b. Is that acceleration upward or downward? ½ cred

$\Sigma F = ma$ $w = mg$

$\Sigma F = 900N - 600N = 300N$ $600N = m(9.8 m/s^2)$ $m = 61.2kg$

$300N = ma$

$300N = 61.2kg(a) \Rightarrow a = 4.9 m/s^2$ upward

a = 14.7

-1

5. A **4kg** tasty treat is tied to the bottom end of a massless rope, and Meredith, standing on a cliff above, is holding the other end of the rope. If Meredith fails to raise the tasty treat a height of **5 meters** in a time of **3 seconds**, an oncoming train will collide with the treat and destroy it. ($V_0 = 0$, Δy, Δt)

(4)

(2) a. Assuming that the treat is starting from rest, what minimum acceleration is required of the tasty treat to prevent its collision with the train?

$\Delta y = V_0 t + \frac{1}{2}at^2$

$5m = \frac{1}{2}a(3s)^2$

$a = 1.11 m/s^2$

(2) b. What minimum breaking strength must the rope have in order for Meridith to be able to raise the treat that fast?

$\Sigma F = 4kg(1.11 m/s^2) \Rightarrow T - 39.2N = 4kg(1.11 m/s^2)$

$\Sigma F = T - 39.2N$ $T = 43.6N$

$W = 39.2N = 4kg(9.8 m/s^2)$

Unit 3 Test, Problem 6

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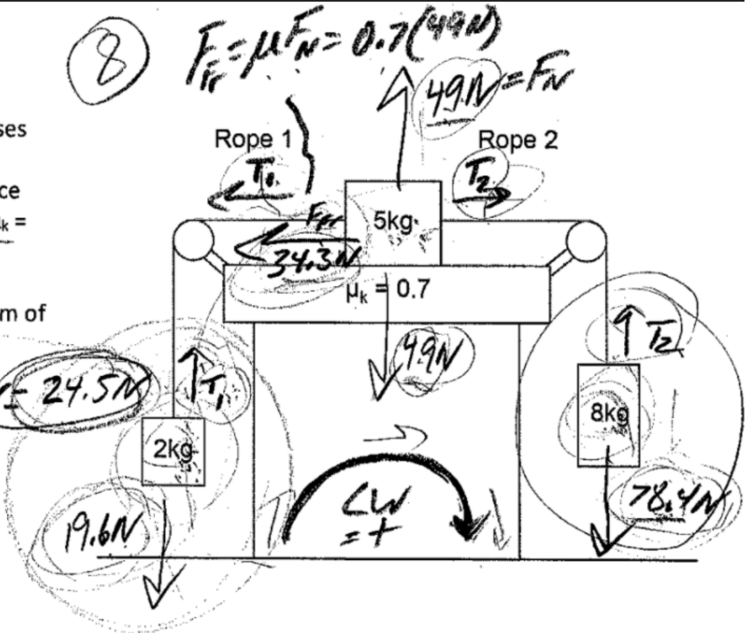
6. The diagram on the right shows three masses connected by frictionless, massless strings passing over frictionless pulleys. The surface that is in contact with the 5kg mass has a μ_k = 0.7. The masses and strings are in motion.



a. Find the acceleration of the entire system of masses and ropes.

$\Sigma F_{15} = 78.4N - 34.3N - 19.6N = 24.5N$

$\Sigma F_{15} = 15kg\,(a)$

$24.5N = 15kg\,(a)$

$a = 1.63\,m/s^2$ CW

b. Find the tension in Rope 1

$\Sigma F_2 = T_1 - 19.6N = 2kg\,(1.63\,m/s^2)$

$T_1 = 22.9N$

2

c. Find tension in Rope 2.

$\Sigma F_8 = T_2 - 78.4N = 8kg\,(-1.63\,m/s^2)$

$T_2 = 65.4N$

2

Unit 4: Newton's Laws in 2-D

Unit 4 Practice Problems 1-2 from Class #30

Physics 200 Name: Key

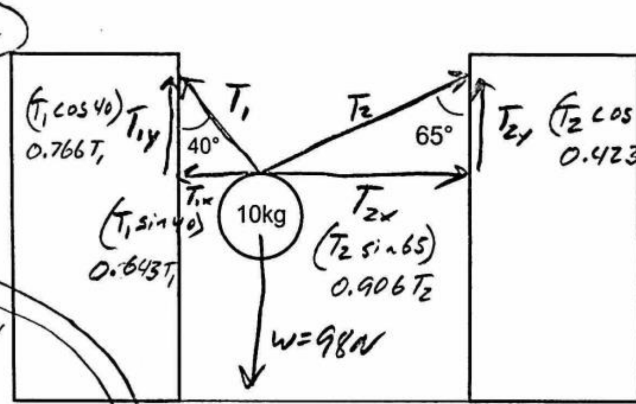
Newton's Laws in 2 Dimensions – Practice Problems #1

$\Sigma F = 0 = \Sigma F_x = \Sigma F_y$

1. The 10kg mass is in static equilibrium. Find the tensions in the two segments of rope.

$\Sigma F_x = 0 = T_{2x} - T_{1x} \Rightarrow T_{2x} = T_{1x}$

$\Sigma F_y = 0 = T_{1y} + T_{2y} - 98N$



$0.906 T_2 = 0.643 T_1$

$1.41 T_2 = T_1$

$0 = 0.766 T_1 + 0.423 T_2 - 98N$

$0 = 0.766(1.41 T_2) + 0.423 T_2 - 98N$

$0 = 1.50 T_2 - 98N$

$98N = 1.5 T_2$

$T_2 = 65.2N$ $T_1 = 1.41(65.2N) = 91.9N = T_1$

2. Find the acceleration of the masses and the tension in the string.

a = $0.61 m/s^2$ CW

T = 46N

$\Sigma F_{11kg} = 49N - 37.8N - 4.5N = 6.7N$

$\Sigma F_{11kg} = 11kg(a)$

$11kg(a) = 6.7N$

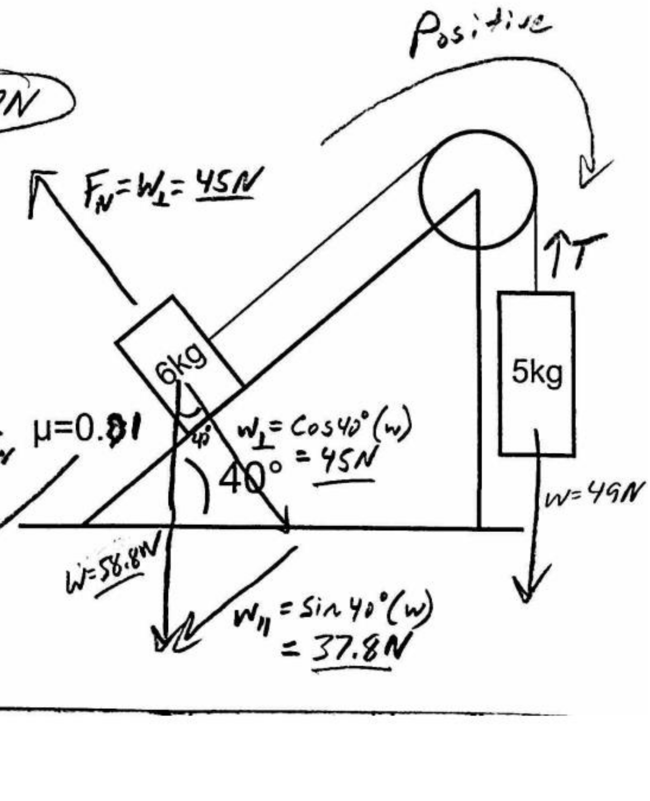
$a = 0.61 m/s^2$ (Clockwise)

$\Sigma F_{5kg} = T - 49N$

$\Sigma F_{5kg} = 5kg(-0.61 m/s^2) = -3.05N$

$T - 49N = -3.05N$

$T = 46N$



Unit 5: Work and Energy

Unit 5 Test, Problems 3

3. Suppose a 450kg racehorse is initially at rest. The horse accelerates across level ground by generating constant power at 15,000W for a full 6 seconds.

$15{,}000\ \frac{J}{s}$

2 a. How much work does the racehorse do during this 6 second period?

$P = \frac{W}{t}$ $15{,}000W = \frac{W}{6s}$ $W = 90{,}000\ J$

2 b. Assuming that none of this work is lost to "other energy," what is the kinetic energy of the horse after 6 seconds?

$W = \Delta KE$ $90{,}000 J$

2 d. What is the horse's speed after 6 seconds?

$KE = \frac{1}{2}mv^2$ $90{,}000 J = \frac{1}{2}(450kg)v^2$

$v = 20\ m/s$

Unit 5 Test, Problems 5-6

5. A 0.15kg graduation cap is tossed directly upward at a graduation ceremony (in a vacuum, on Earth's surface). The cap is released from the thrower's hand when it is 2m above the ground. At that point it is moving upward with 6J of kinetic energy.

2 a. How much PE does the graduation cap have at the moment when it is released? (at h=2m)

$PE = mgh$ $PE_0 = 0.15kg(9.8m/s^2)2m = 2.94J$

2 b. How much PE does the graduation cap have when it reaches its maximum height?

$PE_0 + KE_0 = PE + KE$

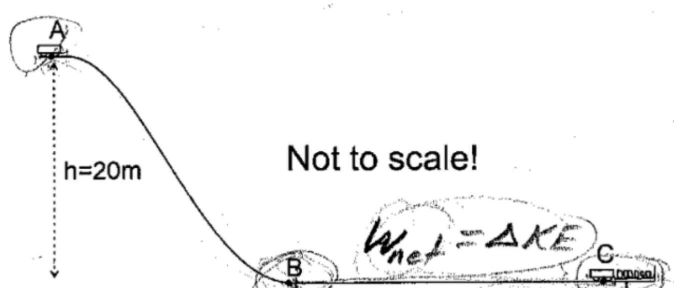
$2.94J + 6J = PE + 0$ $PE = 8.94J$

2 c. How much kinetic energy will the graduation cap have just before it hits the ground?

$PE_0 + KE_0 = PE + KE$

$8.94J + 0 = 0 + KE$ $KE = 8.94J$

6. **Starting from rest, a 600kg** roller coaster leaves point A and travels frictionlessly down a ramp to point B. At point B, the coaster travels horizontally while its brakes apply a **-2,500 N** force of friction to slow it down. As friction continues to slow the coaster, the coaster contacts a huge spring (**k=10,000N/m**), finally coming to stop at point C, after compressing the spring a distance of **3m.** When the coaster comes to a stop, the spring pushes it back again.



2 A. Find the coaster's PE at point A.

$PE = mgh$

$= 600kg(9.8m/s^2)20m$

$= 117,600J$

2 B. Find the coaster's KE at point B.

$W_{net} = \Delta KE$

$PE_0 + KE_0 = PE + KE$

$117,600 + 0 = 0 + KE$ $KE = 117,600J$

115,100 (-1)

2 C. Find the spring's PE at point C.

$PE_{spr} = \frac{1}{2}kx^2 = \frac{1}{2}(10,000N/m)(3m)^2 = 45,000J$

2 D. Between points B and C the coaster experienced friction from its brakes. What is the distance from B to C?

47.04 $PE_B + KE_B + W_{NC} = PE_C + KE_C$

-1 $0 + 117,600J - 2500N(d) = 45,000J + 0$ $d = 29m$

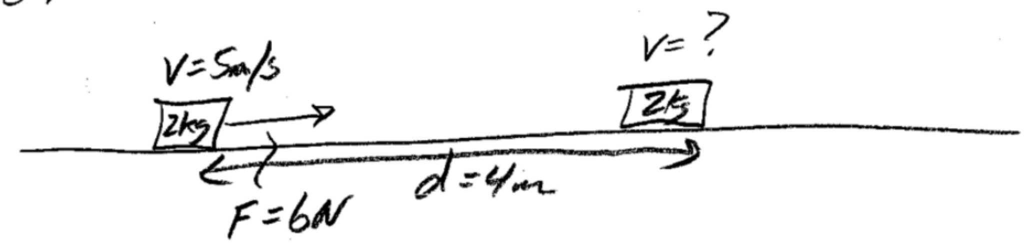
2 E. How much force does the spring exert on the coaster when the spring is fully compressed (compressing over a distance of 3m) at point C?

$F_{spring} = -kx = -10,000N/m(3m) = -30,000N$

Tii 7

Unit 5 Test, Multiple Choice

8.

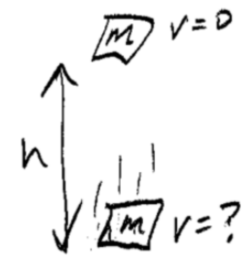


$$PE_0 + KE_0 + W_{NC} = PE + KE$$

$$0 + \frac{1}{2}(2kg)(5m/s)^2 + 6N(4m) = 0 + \frac{1}{2}(2kg)v^2$$

$$\boxed{v = 7m/s}$$

#9.

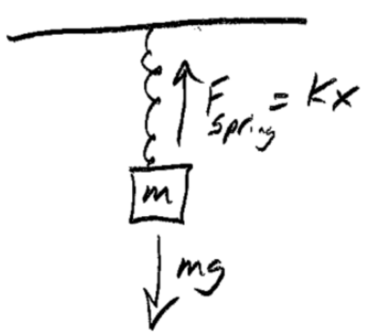


$$PE_0 + KE_0 = PE + KE$$

$$mgh + 0 = 0 + \frac{1}{2}mv^2$$

$$gh = \frac{v^2}{2} \Rightarrow \boxed{v = \sqrt{2gh}}$$

#10.



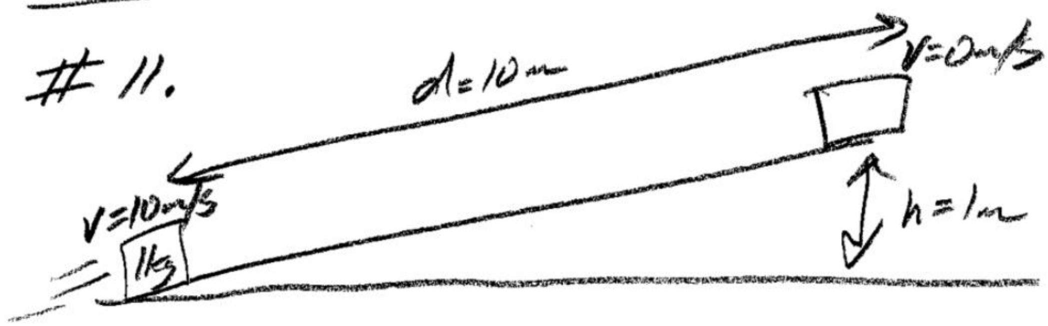
$$\Sigma F = 0$$

$$\Sigma F = kx - mg \Rightarrow kx = mg$$

$$\boxed{x = \frac{mg}{k}}$$

Unit 5 Multiple Choice

11.



$$PE_0 + KE_0 + W_{NC} = PE + KE$$

$$0 + \frac{1}{2}(1kg)(10m/s)^2 + F_{Fr}(10m) = 1kg(10m/s^2)1m + 0$$

($\frac{1}{2}mv^2$) (mgh)

$$50J + F_{Fr}(10m) = 10J$$

$$F_{Fr}(10m) = -40J$$

$$\boxed{F_{Fr} = -4N}$$